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Article

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International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Revinova, Svetlana/Gomonov, Konstantin (2023). A comparative analysis of government policies to promote energy efficiency in the US, China, and India. In: International Journal of Energy Economics and Policy 13 (1), S. 291 - 306. https://econjournals.com/index.php/ijeep/article/download/13790/7137/32087. doi:10.32479/ijeep.13790.

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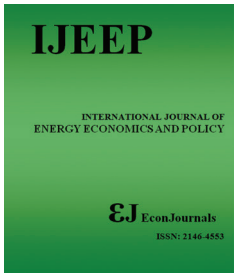

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(1), 291-306.

A Comparative Analysis of Government Policies to Promote Energy Efficiency in the US, China, and India

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Received: 03 October 2022 **Accepted:** 05 January 2023 **DOI:** https://doi.org/10.32479/ijeep.13790

ABSTRACT

This article provides a comparative analysis of Energy efficiency policies in the US, China, and India. During the analysis, all policies were divided into 4 main groups: administrative, economic, production/industrial, and information policies. The study found that energy efficiency policies in the US, China, and India are positively associated with reduced energy intensity. The primary role of the state is to form common goals, adopt legislative and regulatory frameworks, implement state programs, and develop financial support mechanisms for the fulfilment of tasks. This confirms our analysis. The share of administrative policies in the US and China was 76%, and India 60%. In our view, strengthening energy efficiency information policies can play an important role in achieving the goals. The results of the study showed that China is now pursuing a more centralized policy, although the examples of the United States and India show that measures taken in individual states have great potential. In our opinion, the complementarity of the policies pursued will provide a synergistic effect and allow countries to achieve their energy efficiency goals.

Keywords: Energy Efficiency, Energy Saving Policy, Renewable Energy, USA, China, India
JEL Classifications: H0, O2, O5, P5

1. INTRODUCTION

Since the 1970s many countries have implemented policies and programs to improve energy efficiency. At the same time, the potential for energy savings from the implementation of energy efficiency and energy conservation measures is still enormous. According to the International Energy Agency (IEA), the successful implementation of such measures would reduce greenhouse gas emissions by 80%, while significantly improving the security of supply. The IEA estimates that improving the energy efficiency of electrical appliances alone using the best available technologies, as part of a policy aimed at reducing the cost of electrical appliances to the end user, will save up to 1,000 terawatt-hours by 2030 compared to the current situation. The release of cars with lower fuel consumption will dramatically reduce the demand for fuel resources. In rapidly emerging economies, the transport sector is projected to account for 43% of energy demand by 2025, from about 35% in 2008 (UNECE, 2013). The improvement of energy-saving and energy-efficient technologies in construction is another promising direction. The IEA estimates that buildings and appliances could account for one-quarter of the potential reduction in CO_2 emissions by 2050.

Energy efficiency and energy-saving policies have been carried out in an increasing number of countries in recent years. Developing countries, following the developed ones, are realizing the prospects of such an approach. China, India, Brazil, and other countries, where over the past two decades there has been a rapid growth of the economy and demand for energy, in the face of rising prices for hydrocarbon raw materials, have also begun to actively implement such a policy. Emerging economies have great potential to introduce energy efficiency measures in their growing markets, such as transport.

Increasing energy efficiency also means increasing the share of new and renewable energy sources. The ongoing development of new technologies makes the development of renewable energy sources such as solar and wind energy, hydropower, biomass, etc. more affordable and efficient. Both developed and developing countries are creating certain measures to reduce energy consumption. Such measures may be coercive or incentive. In turn, incentive measures can be both economic and motivating to show social responsibility, preserve the environment, rational consumption, etc.

In 2008, at the request of the G8, the IEA developed the 25 Energy Efficiency Policy Recommendations (25EEPR) (IEA, 2011), which was updated in 2011. The recommendations cover seven priority areas: cross-sectoral activities, construction, electrical appliances, lighting, transport, industry, and energy supply. They are based on the IEA's feasibility models, its research on international public policy experience, and the experience of experts and stakeholders (IEA, 2011). The IEA acknowledges that its 25 recommendations are not well suited for direct application in non-OECD countries. In 2014, it produced the first document in the series "Recommendations for Energy Efficiency Policies in the Regions" aimed at the Arab countries of the southern and eastern Mediterranean (SEMED) (IEA, 2014) and considering the need for the recommended policy to be adapted to the cultural, political, and linguistic environment of different countries.

The study Energy Efficiency Policies – What works and What Doesn't (World Energy Council, 2013) provides eight key recommendations to members of the World Energy Council for optimal energy efficiency policies. These include:

1. Energy prices should reflect real costs and give more incentives to consumers.
2. Consumers should be better informed.
3. Innovative financing tools should be implemented to support consumers' investments.
4. The quality of energy-efficient equipment and services should be controlled.
5. Regulations should be enforced and regularly strengthened.
6. Behaviours should be addressed as much as technologies. ICT could help.
7. Monitoring achievements and the impacts of measures is necessary to check the real impact of energy-efficiency policies.
8. International and regional cooperation should be enhanced.

A United Nations publication released by the Economic Commission for Europe in 2017 states that best practices in energy efficiency policy are likely not to be limited to a certain set of specific solutions; only policies whose expected results can be quantified deserve consideration; The most likely to succeed is a policy that meets local preferences and considers the specifics of the local market. An important criterion here is its ability to influence the market by encouraging investment in energy efficiency (UNECE, 2017).

The UNECE has identified key criteria for an optimal energy efficiency policy: the weight of the results; complementarity, synergy, and integration; political coherence, where the effectiveness of the policy and obtaining the desired effect depending on the position of central, regional, and local authorities; market feasibility and impact on the market, i.e. the possibility of implementing this policy in the conditions of the global and local markets for energy-saving technologies, its attractiveness for management and the ability to mobilize the necessary investments (UNECE, 2017).

The purpose of this study is to compare government support measures to improve energy efficiency and increase renewable energy production in the countries that are both leaders in energy consumption and are the largest emitters of CO_2: the United States, China, and India.

2. LITERATURE REVIEW

Energy efficiency is an important energy policy strategy around the world to reduce energy consumption, secure energy supply, and reduce greenhouse gas emissions. Today, energy security issues are very acute. Almost daily there are proposals for new measures to reduce energy consumption. Energy consumption issues play an important role in global policy debates among politicians around the world (Salari et al., 2021). According to Bertoldi and Mosconi (2020), energy policy contributes to the reduction of energy consumption. In the absence of an energy policy, consumption in the EU28 plus Norway would have been about 12% higher in 2013, in line with the findings of other authors. Policy-driven energy savings appear to be higher in the industry (20.4% savings in 2013 for the EU28 plus Norway), at the average in the household (8.5%) and transport (11.9%), 18 while in the service sector the scale and significance of the effect seems insignificant.

Several researchers have concluded that an increase in the efficiency of resource use in many cases is associated with both the rebound effect (in Russian, the term "rebound effect" or "boomerang effect" is more often used) and the Jevons paradox. The rebound effect is a broad category that represents all cases where efficiency gains do not lead to the full expected benefit or even backfire. The Jevons paradox refers to an extreme rebound, sometimes referred to as the "reverse effect," where efficiency gains are associated with increased consumption (Cattaneo, 2019; Saunders, 2013). It is noted that efficiency savings are often channeled into expanding production and consumption. Thus, while efficiency gains can, in principle, reduce energy demand and promote sustainability, the challenge is how to apply this without inadvertently driving up consumption (Adua et al., 2021). The economics literature suggests that energy savings are often smaller than implied by utility-reported results, but some interventions appear to be cost-effective relative to the marginal cost of electricity supply (Gillingham et al., 2018). The results of econometric studies show that the studies analyzing the effects of energy efficiency policies estimate a significant impact of these policies on energy demand and the price of related durable goods (Labandeira et al., 2020).

Governments apply a wide variety of energy efficiency policies. Studies of energy efficiency policy instruments indicate that implementation of a single separate policy instrument will

most likely fail to achieve the expected results of overcoming barriers to energy efficiency and simultaneous implementation, or a combination of several policy instruments is preferable. If more than just one separate policy instrument aiming at improving energy efficiency is employed, then coordination between two or more policy instruments as well as the correct sequence of implementation of policy instruments is essential for achieving success (Aboltins and Blumberga, 2019). Cattaneo (2019) considers the effectiveness of different types of policies as instruments for the various barriers they are designed to remove. To date, countries have applied various measures and policies. Existing laws and regulations on energy efficiency, energy conservation, and the use of renewable energy sources are being adopted and improved (Obeng-Darko, 2019; Nasr et al., 2020). A fairly large number of different measures are associated with industrial modernization, ensuring the level of energy security by modernizing the network of existing power plants, increasing their level of reliability and continuity (Sabishchenko et al., 2020), developing investment projects to attract additional investment in this industry (Kim et al., 2017; Steffen, 2018), building standards and appliance coding (Ratner et al., 2021). Energy efficiency policies in the manufacturing industry are of the utmost importance. For example, in the EU, manufacturing still uses approximately 25% of total EU final energy consumption (Andrei et al., 2021). For countries such as China, where the number of residential buildings and other buildings is growing at a rapid pace, the question is how to improve the energy efficiency of a rapidly growing number of new buildings and accelerate the modernization of a huge number of existing buildings. China has gradually changed its building energy efficiency policy portfolio from a purely regulatory approach with mandatory building codes at an early stage to voluntary green building initiatives (Li and Shui, 2015). India is expected to have 40 billion m^2 of new buildings built by 2050. Buildings today account for one-third of India's total energy consumption and energy consumption in buildings is expected to continue to rise, fueled by rapid income and population growth. The existence of energy regulations for both commercial and residential buildings can lead to an additional 10% in energy savings (Yu et al., 2017). Great importance is attached to economic incentives, such as tax incentives, and the provision of fixed and preferential tariffs by the state (García-Álvarez et al., 2017; El Iysaouy et al., 2019); Financial incentives or disincentives in the form of electricity tariffs can be successfully used to encourage energy efficiency (Prasanna et al., 2018). Environmental taxes and payments can simultaneously change important parameters of environmental, energy, and economic security, as well as sustainability (Štreimikienė et al., 2021). The regulator should optimally offer a menu of incentive-compatible tariffs (Abrardi and Cambini, 2015).

Informing the public about energy-saving opportunities and about the prospects for using non-traditional energy sources (Tampakis et al., 2017), awareness-raising measures, which in some cases are targeted at certain groups of the population (Komendantova et al., 2018). A study in Italy, Poland, Sweden, and the UK found that households prefer effective policies, dislike personal costs, and prefer non-coercive to coercive instruments; further, trust in government helps make coercive policies such as taxes more acceptable, whereas higher environmental identity makes consumption limits more acceptable (Faure et al., 2022). Knowledge, awareness, and understanding of public policies that support and implement renewable energy are considered important in determining public understanding of renewable energy (Derasid et al., 2021).

At the same time, there are very clear differences in approaches to energy conservation in different countries, related to the peculiarities of the national mentality, cultural preferences, and stereotypical behaviours. However, an important common feature of developed countries is the concentration of policies on achieving energy savings at the stage of energy use. Yang and Yu (2015) established four key findings: (1) It is necessary for the government to constantly revise or strengthen national energy efficiency policies to make these policies suitable for the changing national realities; (2) an effective government policy in one country may not apply to another country, although many national government policies can be shared among different countries; (3) there is no widely accepted methodology for evaluating the effectiveness of energy efficiency policies; (4) coordination among the national government policymakers and policy implementers is increasingly important.

The energy transition in developing countries mainly consists of integrating renewable energy and energy efficiency to achieve sustainability (Dhakouani et al., 2019). The modern development of renewable energy is largely due to significant government intervention in the market. Direct support programs have had a direct impact on the actual construction of industrial infrastructure. Studies have shown that renewable energy in the countries under study has favourable prerequisites for development, but their implementation requires targeted and coordinated actions by the state and business (Smirnova et al., 2021; Kersey et al., 2021). In most countries, there is a significant and positive relationship between renewables and economic growth (Ullah et al., 2021). However, the situation differs from country to country. Thus, renewable energy does not affect the environmental load in Russia and India. Therefore, these countries need to differentiate their current renewable energy production policies to achieve their sustainable development goals (Pata, 2021). In the current decade, China is the leading country in the development of renewable energy (Ji and Zhang, 2019).

The energy market of modern China is characterized by the large-scale application of low-carbon electricity generation technologies and significant investments in the production of renewable energy sources. The country is aiming to install specialized capacity to produce large amounts of wind and solar electricity by reforming the existing energy system and assessing resources. As a result of government reforms in China, by 2050 the renewable energy sector will produce 75-80% of electricity. This will positively impact the environment by reducing carbon and other emissions (Dai et al., 2016). In addition, studies point to an increase in the share of renewable energy in China to 63% by 2050 (Gielen et al., 2019). The Chinese government has adopted various energy policies to promote green industrial development. However, the effectiveness depends on the type of policy and the

region. Renewable energy and energy conservation policies have a stronger impact than policies aimed at modernizing traditional fossil fuel industries. Moreover, it takes longer for industrial upgrading policies to be effective than the other two types (Zeng et al., 2020). The development of the renewable energy sector and the modernization of the energy infrastructure play a strategic role in China's commitment to combat climate change. Politicians and authorities have made great efforts to implement them. But one of the key constraints to China's energy revolution is the financial challenges that are inevitably linked to the country's financial development (Ji and Zhang, 2019).

In India, the country with the highest population growth in the world, the use and dissemination of renewable energy technologies are a prerequisite for the further development of the country. The main instruments of the state are the sale of capacities through auctions, "green tariffs" (Feed-in tariff, FIT), and tax incentives (Eren et al., 2019).

Expanding energy conservation and efficiency improvements in every sector across the country is one of the most cost-effective tools to reduce US energy imports, the trade deficit, and energy's environmental impact. For these reasons, energy conservation and efficiency have been important elements of US energy policy since the oil embargo and price hikes in the 1970s (Dixon et al., 2010). The US states are central to shaping energy efficiency policy in the United States, often focusing on areas intentionally or unintentionally ignored by the federal government (Adua et al., 2021). Ollier et al. (2020) found that EU Member States, especially those considered climate leaders, tend to prioritize renewable energy over energy efficiency when setting targets. In addition, almost every country performs well in either renewable energy or energy efficiency, but rarely in both.

3. MATERIALS AND METHODS

The IEA database (https://www.iea.org/policies) was used to compare the energy efficiency policies of the US, China, and India. The IEA's Policies and Measures Database provides access to information on past, existing, or planned government policies and measures to reduce greenhouse gas emissions, improve energy efficiency and support the development and deployment of renewables and other clean energy technologies. The database gets data from the IEA/IRENA Renewable Energy Policies and Measures Database, the IEA Energy Efficiency Database, the Addressing Climate Change database, and the Building Energy Efficiency Policies (BEEP) database, along with information on CCUS and methane abatement policies. This policy information has been collected since 1999 from governments, partner organizations, and IEA analysis. The study used statistical data from the Enerdata Yearbook (https://yearbook.enerdata.net/). During the study, the methods of descriptive statistics, and systemic and comparative analysis were used.

3.1. Analysis of Statistical Indicators

In 2021, global energy consumption increased by 5% after a 4.5% decline in 2020 caused by the coronavirus pandemic. This is 3 points above the annual average (2% per year) observed between 2000 and 2019. Energy consumption increased in most countries: +5.2% in China (after +2.2% in 2020), +4.7% in India (after -5.6% in 2020), +4.7% in the US (after -8.6% in 2020), +9% in Russia (after -4 % in 2020) and +4.5% in the EU (after -6.8% in 2020) (World Energy and Climate Statistics - Yearbook, 2022). The leaders, in terms of total energy consumption, in 2021 are China 3652 Mtoe, USA - 2132, and India - 927 (Figure 1). The same countries are also leading in terms of total energy production China 2947 Mtoe, USA - 2205, India - 625 (Figure 2). It should be noted that according to this indicator, India took the 4th place, leaving Russia behind (1516 Mtoe). As can be seen, China and India do not cover energy costs from their products but are forced to purchase additional energy. The situation in the USA is somewhat better, but for them, the acquisition of additional energy is an urgent issue. The governments of these countries, like most other countries in the world, aim to reduce electricity consumption. From 2000 to 2021 of the countries under consideration, only the United States managed to achieve a decrease in this indicator by 0.3%. In China, the increase was 5.7% over the same period, and in India - 1.3% (Table 1).

Table 1 presents data on the main indicators of energy consumption for the period from 2000 to 2021. They show that the United States has been the most successful in terms of both energy consumption and emissions reduction. Energy production increased annually in all countries studied. At the same time, energy consumption in India and China grew faster than production, which makes energy efficiency issues even more relevant for these countries.

For the period from 2000 to 2021, the annual growth in electricity production in China was 9.2%, in India -5.3%, in the United States - 0.4%, and consumption in China was 9.5%, in India - 6.4 %, USA - 0.4%, That is, consumption in China and India is growing at a faster pace than production. In the US, they grow the same way. To date, a universal and internationally comparable indicator in the field of energy efficiency is the energy intensity of GDP. The graph below (Figure 3) demonstrates the decline in this indicator both in the US and in the fast-growing economies of India and China over the past 30 years. China has been the most successful, with a reduction of more than 70%. It can be noted that in recent years the rate of decline has slowed down in all countries.

Increasing energy efficiency also means increasing the share of new and renewable energy sources. Norway accounts for the largest share of renewable energy sources in electricity generation. China ranks 16th (out of 44 countries surveyed), and the US and India 23rd and 24th respectively. At the same time, an annual increase in this share is observed, although the growth rate has decreased (Figure 4).

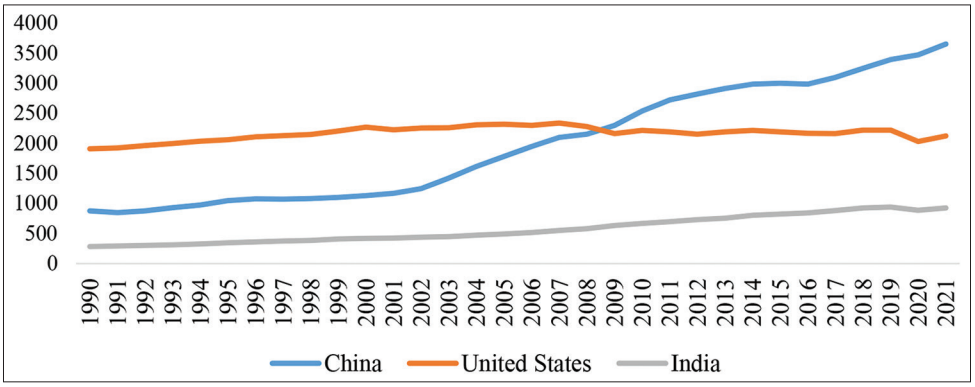
The result of the energy efficiency policy is not only a reduction in energy consumption but also a reduction in greenhouse gas emissions. The United States, China, and India are the world leaders in CO_2 emissions, which only increases the need for urgent action to implement strategies to reduce the harmful effects on the environment and combat climate change. According to Enerdata, among the countries under consideration, only the United States has so far managed to achieve some success (Figure 5).

Table 1: Growth rates of selected energy consumption indicators, 2000-2021 (%/year)

	China	United States	India
Total energy production (Mtoe)	4,7	1,4	3,0
Total energy consumption (Mtoe)	5,7	-0,3	3,9
Energy intensity of GDP at constant purchasing power parities (koe/$15p)	-2,7	-2,2	-2,0
Electricity production (TWh)	9,2	0,4	5,3
Electricity domestic consumption (TWh)	9,5	0,4	6,4
CO_2 emissions from fuel combustion ($MtCO_2$)	5,9	-1,1	4,4
Share of renewables in electricity production (%)	12,2	11,7	6,8

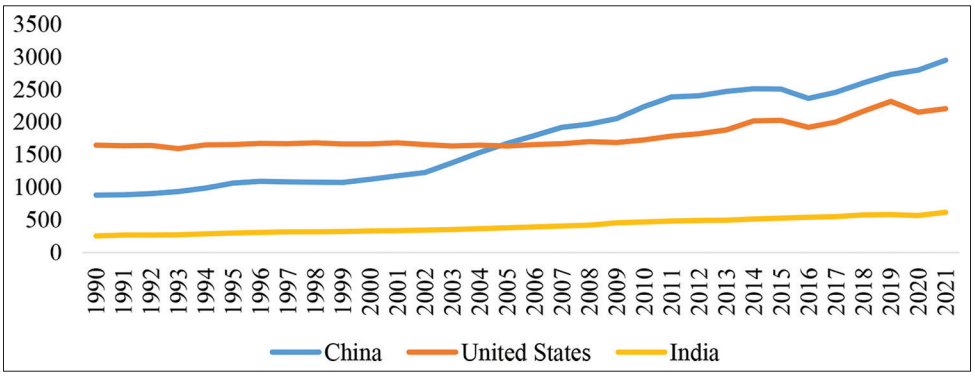
Source: World energy and climate statistics - yearbook, 2022

Figure 1: Total energy consumption (Mtoe)



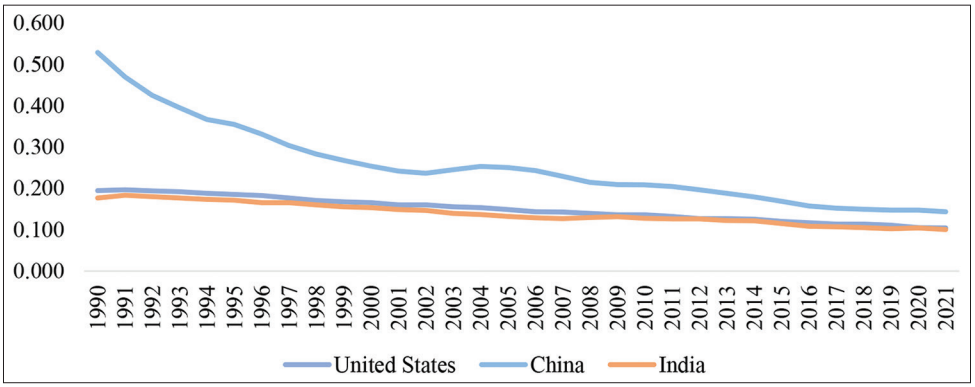
Source: World energy and climate statistics - yearbook, 2022

Figure 2: Total energy production (Mtoe)



Source: World energy and climate statistics - yearbook, 2022

Figure 3: Energy intensity of GDP at constant purchasing power parities (koe/$15p)



Source: World energy and climate statistics - yearbook, 2022

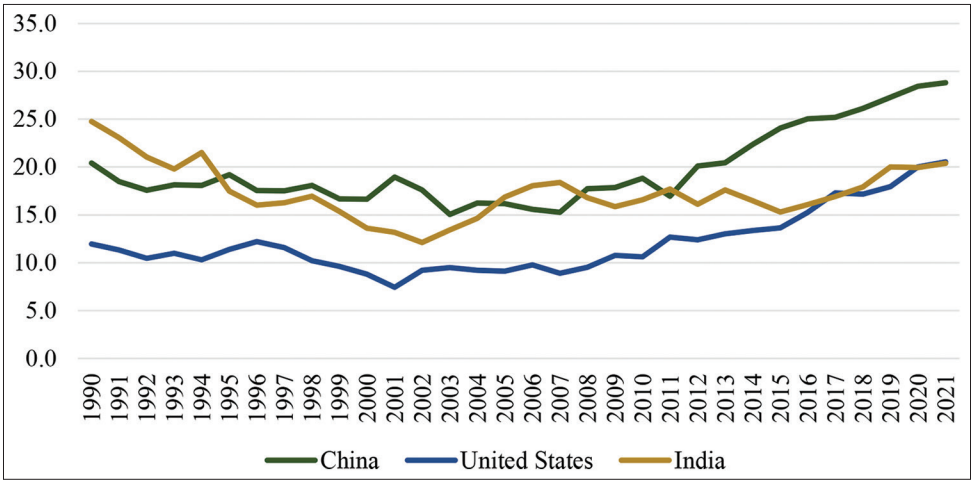
The governments of the United States, India, and China, among many others, aim to reduce dependence on additional energy purchases by improving their energy efficiency through the application of special policies.

3.2. Energy Efficiency Policy Analysis

The IEA/IRENA database is one of the sources of information on the ongoing state policies and measures to reduce energy efficiency in various countries. According to the agency, 316 different policies in this area have been adopted in the United States, 120 in China, and 123 in India. In China, the first government measures related to energy efficiency were adopted in 1989 in "GB 12021.3-1989 MEPS fixed speed air conditioners" and "Minimum Energy Performance Standards (MEPS)." In India, the National Energy Conservation Awards were announced in 1991.

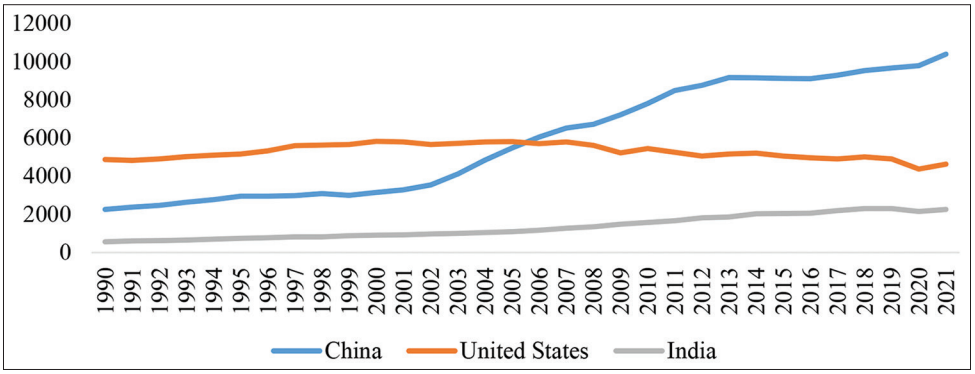
Figure 6 shows the number of policies adopted in the countries under consideration from 1974 to 2021. It shows that initially, the United States overtook India and China in terms of the number of measures taken, but already in 2015-2016, simultaneous peaks are visible in all countries. In 2017-2018,

Figure 4: Share of renewables in electricity production (%)



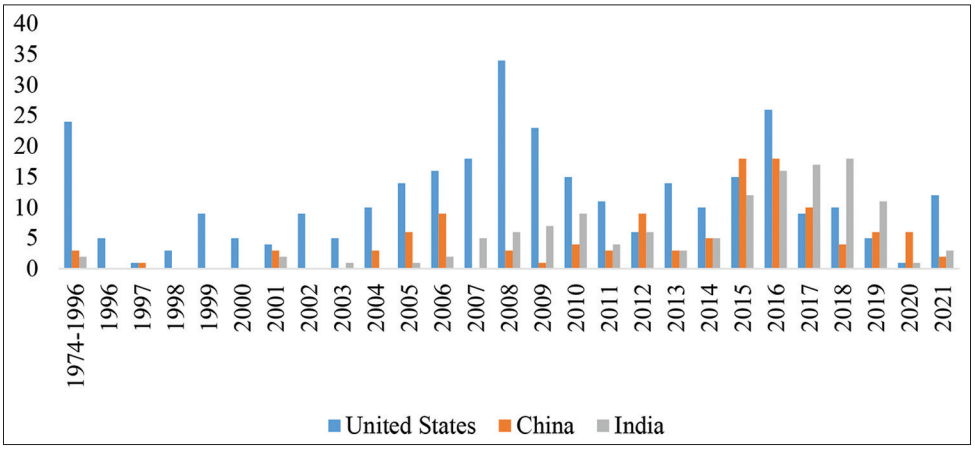
Source: World energy and climate statistics - yearbook, 2022

Figure 5: CO_2 emissions from fuel combustion ($MtCO_2$)



Source: World energy and climate statistics - yearbook, 2022

Figure 6: Energy efficiency policy, by years



Source: Policy database – data and statistics

India jumped and overtook the US for the first time, while China saw an increase in 2020 when India and the US saw little to no new measures.

After analyzing the available documents, we propose to divide the existing policies into 4 main groups (Table 2).

1. Administrative policies. This group includes Regulation, Government provided advice, Strategic plans, Targets, plans, and framework legislation.
2. Economic policies. This group includes policies related to Payments, finance, taxation, transfers, and Grants.
3. Production/Industrial Policies. This group includes policies: Minimum energy performance standards, Energy/CO_2 performance labels, Performance-based policies, Codes and standards, Comparison labels, and Building codes and standards.
4. Information policies: Consumer information, Information and education, Public information.

Note that some policies can be included in several groups at the same time.

The analysis carried out by the number of applied policies in China, India and the United States is shown in Table 2.

The presented data show that India and China have adopted approximately the same number of government measures and policies aimed at energy conservation and energy efficiency, but this is more than 2 times less than in the United States. In the US and China, legislative and government measures (including government programs) are about the same in number. But, at the same time, one of the measures of the US state policy is the Government provided advice, which can also be attributed to the measures of information stimulation of the population and business, which is not in either China or India. In India, the number of administrative measures is less. Separately, it is worth mentioning information policies. In recent times, informing and stimulating individuals and private companies has become of paramount importance. At the same time, in China, such measures are not enough. In India, the number of these measures is comparable to the United States.

According to their jurisdiction, policies can be divided into international, national, provincial, or states, city/municipal (Table 3).

Of the 316 US policies, about 40% are state-based and 60% are state-level. In India, 80% is accounted for by national politicians. In China, only 6 out of 120 government policies are municipal. That is, the state policy of China is regulated by the government of the country.

Let us consider only those government measures that have not yet ended, but continue to operate. We see that the United States leads in terms of the number of both ongoing and announced measures to increase energy efficiency, and China remains the least active (Table 4).

Let's use our classification to analyze the measures of state policy in the field of energy efficiency only among the measures that continue to operate (Table 5).

Information policies in the United States account for about 25%, economic incentives for about 39%, administrative policies - for 71%, and production, and industrial policies – for 39%. In China, information policies account for about 13%, economic incentives

Table 2: Energy Efficiency Policies of the United States, India, and China for the Entire Period of Observation (Including National and Regional, Ended and Ongoing)

Group	Policy type	USA	China	India
Administrative Policies	Regulation	215	74	73
	Government provided advice	41	-	-
	Strategic plans		19	
	Targets, plans, and framework legislation		23	
	Targets		11	
	Total*	239	91	73
Economic Policies	Payments, finance, and taxation	115	31	34
	Payments and transfers	72	22	26
	Grants		12	
	Total*	116	31	37
Production/Industrial Policies	Minimum energy performance standards	38	24	30
	Energy/CO_2 performance labels	-	-	29
	Performance-based policies	55	-	28
	Codes and standards	71	40	24
	Comparison labels	-	-	24
	Building codes and standards	79	-	
	Total*	186	48	65
Information Policies	Consumer information	-	-	27
	Information and education	67	13	39
	Public information	54	-	-
	Total*	90	13	47

*The same policy can be assigned to several groups. Source: Policy database – data and statistics

for about 25%, administrative policies -for 80%, and production and industrial policies – for 58%. In India, information policies account for about 31%, economic incentives for about 25%, administrative policies - for 62%, and production and industrial policies – for 30%.

To date, the largest number of measures taken to inform and educate the population and businesses are being implemented in India. In China, most of the actions taken are legislative and legal acts. Economic incentives to increase energy efficiency are mostly implemented in the United States.

Energy efficiency policies can also be divided by the industries to which they apply (Table 6).

In all countries, most of those applied are in the buildings, residential, services, power, heat, and utilities, services sector.

Table 3: Energy efficiency policies by Jurisdiction

Jurisdiction	USA	China	India
National	189	112	97
State/Provincial	116	1	23
International	8	-	-
City/Municipal	2	6	3
Unknown	1	1	-

Source: Policy database – data and statistics

Table 4: Energy efficiency policies by status

Status	USA	China	India
In force	267	79	107
Ended	46	40	15
Announced/Planned	3	1	1

Source: Policy database – data and statistics

Only India has policies applied in the agriculture sector: "EESL Solar Agriculture DSM," "Scheme on Energy Conservation in Agriculture Sector in Haryana," and "Agricultural Demand Side Management (AgDSM) Program." In India, the agricultural sector is interested in alternative energy, and there are several reasons for this (Kumar and Pal, 2018): there is a fairly large number of areas that are not always suitable for their main use in farms (Liu et al., 2017); renewable energy sector – good additional income; the possibility of energy independence, since electrical networks located in remote rural areas sometimes fail, leading to periods without centralized electricity, and this can be especially negative during the harvest season (Martinho, 2018).

Since 1996, 144 measures have been adopted in the United States, 147 in China, and 76 in India related to the policy of using renewable energy sources. The first document in the United States was adopted back in 1974: Geothermal Energy Research, Development, and Demonstration Act, Solar Energy Research Act, and Solar Heating and Cooling Demonstration Act. In China, the first RE document was adopted in 1996: the Brightness Program, and the next only in 2001: The 10th Five-Year Plan for Economic and Social Development of The People's Republic Of China (2001-2005), where there is a part regarding RE. India has adopted 76 different policies, the first being the Rajasthan Policy for Promoting Generation of Electricity from Wind 2012 in 2000.

The data in Figure 7 demonstrates that renewable energy policies in the United States were adopted much more actively than in India and China until 2010, and then there was a surge in 2021. China and India have been paying great attention to this area since 2012.

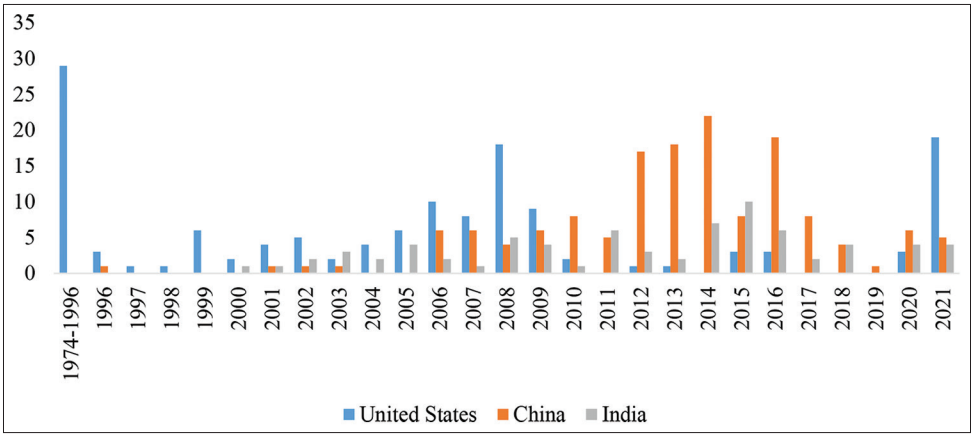
The renewable energy policies presented in the database are also divided into four main groups: administrative policies, economic

Table 5: State policies in the field of energy efficiency are only among the measures that continue to operate

Group	Policy type	USA	China	India
Administrative Policies	Regulation	190	54	66
	Government provided advice	40		
	Strategic plans		9	
	Targets, plans, and framework legislation		12	
	Targets			
	Total*	190	63	66
Economic Policies	Payments, finance, and taxation, including	93	18	27
	Payments and transfers	56	11	19
	Grants			
	Total*	103	20	27
Production/Industrial Policies	Minimum energy performance standards	34	19	27
	Energy/CO_2 performance labels			26
	Performance-based policies	53	8	25
	Codes and standards	50	30	
	Comparison labels			21
	Building codes and standards	64	8	
	Total*	144	46	32
Information Policies	Consumer information			24
	Information and education	65	10	33
	Public information	52		
	Total*	65	10	33

*The same policy can be assigned to several groups. Source: Policy database – data and statistics

Figure 7: Renewable energy policy, by years



Source: Policy database – data and statistics

Table 6: Energy efficiency policies by the industry

Industry	USA	China	India
Transport	45	45	19
Buildings, residential, services, power, heat, utilities, services	221	66	67
Industry	33	18	21
Multi-sector (economy-wide)	84	20	31
Agriculture			3

Source: Policy database – data and statistics

policies, policies in the field of production and industry, and information policies (Table 7).

State policies in the field of renewable energy use are largely driven by economic incentives. Their share is quite high in all three countries. It should be noted that information incentives are present only in the United States.

The US Action Plan, which is based on "Vision 2025", contains five key recommendations to achieve the goal of cost-effective energy efficiency. A feature of the US energy efficiency policy is the very widespread use of various economic incentives and information about energy-saving opportunities. That is, the primary efforts are directed not toward coercion, but toward interest. The economic stimulus measures, approved by Congress and approved by the President, provide for a significant increase in resources for energy efficiency projects. These measures also promote the development of a workforce with experience and training in energy efficiency. Given the regulatory structure of energy utilities in the US, many of the measures are taken at the state level. States are free to determine how they can incentivize energy conservation and job retention in the long term. The United States has federal programs to promote energy conservation and ways to improve energy efficiency. Let's consider some types of information about the possibilities of energy saving. The websites of state authorities and energy efficiency funds provide information free of charge in a form accessible to the public, as well as libraries of regulations involved in the implementation of state energy saving and energy efficiency programs.

Energy Star, a voluntary certification program for household appliances and electrical appliances, launched in 1992, is an indicator of the energy efficiency of household appliances, electronic devices, etc. In addition, the Energy Star label helps owners track the efficiency of their commercial buildings. (Australia, Canada, Japan, New Zealand, Taiwan, and the European Union later joined the program). Tennessee organizes specialized energy camps to train schoolteachers on how to teach energy and energy conservation in schools. Participants also receive the Tennessee-created educational tool KitBooks, which combines practical and theoretical materials. In 2016 and 2017, 160 teachers visited such camps. In Nebraska, the Nebraska Dollar and Energy Saving Credit programs help families and businesses invest in energy efficiency. The Weatherization Assistance Program is aimed at supporting low-income families in terms of saving thermal energy. The Industrial Assessment Centers provide energy consultancy to small and medium-sized enterprises and train students to conduct energy assessments. In 2021, the "DOE training Program to improve Energy Efficiency" was launched. The US Department of Energy (DOE) announced a USD 30 million funding in for new workforce training initiatives as part of its actions toward reducing the carbon footprint of buildings. Residential and commercial buildings are responsible for a third of GHG emissions in the US, use about 40% of the nation's energy, and waste more than $100 billion annually due to energy inefficiency (DOE Training Program to Improve Energy Efficiency – Policies). U.S. Department of Energy (DOE) announced up to $52.5 million for DOE's Industrial Assessment Centers that help American manufacturers and wastewater treatment facilities improve their efficiency, save money, and reduce their carbon footprint. These university-based training programs also create a pipeline for students looking to join the growing clean energy economy (Support for Industrial Assessment Centers – Policies).

Among the economic incentive measures, tax incentives for individuals are widely used for taxation of vehicles with hybrid engines, electric engines, cars using gas and hydrogen as fuel, fuel cell cars, cars with lean burn engines; or slow vehicles. Tax credits for businesses (from 10% to 30% of the number of costs) are common for taxpayers introducing alternative energy sources (solar energy, microturbines, small wind farms, thermal power plants with an efficiency above 60%, the use of fuel cells, geothermal sources); purchasing household appliances that meet the

Table 7: State policies in the field of energy efficiency are only among the renewable energy

Group	Policy type	USA	China	India
Total operating		98	79	64
Administrative Policies	Regulation	28	30	24
	Strategic plans	10	18	16
	Targets, plans, and framework legislation	25	17	20
	Total*	44	42	33
Economic Policies	Payments, finance, and taxation	58	24	35
	Payments and transfers	34	21	18
	Taxes, fees, and charges			22
	Grants	32	6	
	Feed-in tariffs/premiums		7	7
	Performance-based payments		6	
	Tax credits and exemptions			14
	Total*	59	30	36
Production/Industrial Policies	Performance-based policies		8	11
	Codes and standards	12	11	
	Total*	12	14	8
Information Policies	Information and education	27		
	Public information	16		
	Total*	27	-	-

*The same policy can be assigned to several groups. Source: Policy database – data and statistics

requirements of the Energy Star 2007 energy efficiency standard; who built residential buildings if their energy efficiency is 30-50% higher than the requirements of the energy efficiency standard; for the use of energy from alternative sources (wind, landfill gas, household waste, geothermal energy, micro-hydro, tidal and wave hydroelectric power plants). Tax credits to individuals for work to improve the energy efficiency of houses (up to 30% of the number of costs incurred) when using: thermal insulation; energy efficient windows and doors; heat-insulating roofs; heat pumps; efficient water heaters; centralized air conditioning and ventilation; gas; biomass heat generators; means of solar energy; fuel cells; small wind farms; geothermal heat pumps.

Tax deductions, which are determined in the amount of the deduction per square meter of the building separately for the use of various ways to improve energy efficiency: insulation; conditioning; lighting, etc. Soft loans are issued. The government allocates grants for scientific research in the field of RES. The White House launched an innovation effort to create jobs while tackling climate change, including a new research working group, the outline for an innovation agenda, and a $100 million grant program from the Department of Energy for low-carbon energy technologies. In 2021 and early 2022 alone, 16 measures were taken to stimulate the use of renewable sources. Among them are the Infrastructure and Jobs act: clean hydrogen initiatives, USD 20 Million to Lower Costs of Geothermal Drilling, Biofuels Research to Reduce Transportation Emissions, Funding for solar deployment in underserved communities, and many others.

Speaking to the UN General Assembly, China announced that it would become carbon neutral by 2060, in what many see as a landmark move. At the same time, the target is set at a later stage than in other countries that have set such targets for 2030-2050 (Darby, 2020). High energy consumption in China is explained by the structure of the economy, in which most of the GDP is formed not by the service sector and high-tech industries, but by industry. In the achieved good results of the PRC in improving energy efficiency, the role of the state is high. The main directions for improving the energy efficiency of the Chinese economy are related to the optimization of the industrial structure, the improvement of the taxation and pricing system, the increase in the scientific and technological level, and the improvement of the control and management system (Bakhtiyarova, 2016). China is constantly developing and implementing state programs aimed at the current and strategic development of the energy sector with an emphasis on the development and use of new types of energy, optimization of the energy structure, energy savings in all sectors of the economy, and environmental protection. At the same time, the implementation of energy efficiency improvement programs takes place in close cooperation between the state, public and private companies based on fundamentally developed plans that regulate the time frame, and technical, financial, and commercial parameters of specific projects.

The Chinese government has concluded that traditional measures to reduce energy intensity are not enough and has begun to develop a special policy aimed at stimulating energy conservation. Since 2006, the Top 1000 program has been operating in China, which was modelled based on European long-term targeted agreements. This program has shown the greatest efficiency. The "Top-1000" program involves enterprises in the metallurgical, chemical, paper, and textile industries, as well as electric power, oil refining, coal mining, and building materials production. The next step was the Top 10,000 program. It covers not only the industry but also transport companies and large facilities in the service sector. More than 10,000 industrial enterprises (with an energy consumption of more than 10,000 toes/year), about 160 transport companies, and 1,800 large municipal buildings (with an energy consumption of more than 5,000 toes/year) are involved in this program). Using world experience, China has introduced and currently effectively uses the following energy saving and energy efficiency mechanisms: technical regulation in the industry: construction and operation standards; energy consumption standards; construction standards for residential and commercial buildings and structures;

planned tasks in the field of energy efficiency and energy saving; energy management, verification, and measurement standards; public procurement system for energy efficient equipment; tax benefits (depreciation, income tax, property tax, VAT; government payments for saved energy; Environmental taxes; energy audit; labelling of equipment, machinery, and buildings, etc. (Semenova, 2020).

The new automotive energy plan (2021-2035) states that by 2035, all new vehicles sold in China must be equipped with "new energy." Half of them must be an electric, fuel cell, or plug-in hybrid, and the remaining 50% hybrid vehicles. In turn, the regions are developing measures to stimulate the purchase of electric vehicles. For example, the city of Beijing decided to support its transportation business to replace its light trucks with a new type of truck with a subsidy of 70 yuan per unit from October 1, 2020, to August 31, 2021. Only businesses that replace more than 5 trucks can be supported under the subsidy scheme. China has extended its electric vehicle (EV) subsidy policy, which was due to end in 2020, by 2 years to boost EV sales.

China implements 14th Five-Year Socio-Economic Development Plan and long-term goals for 2035. Key energy/climate targets set out in the Plan by 2025 include a 13.5% reduction in the country's energy intensity, an 18% reduction in CO_2 emission intensity, an increase in the share of non-fossil energy to approximately 20% of total energy consumption by 2025, the nuclear power capacity of 70 GW and a 9% increase in forest coverage. China's National Energy Administration (NEA) has set a target for renewable energy to account for more than half of the total installed capacity by 2025. An important goal of the plan is the reconstruction of existing buildings with an area of more than 350 million square meters. to improve their energy efficiency. In addition, during the 5 years, China plans to build 50 million square meters of buildings "with almost zero energy consumption." The document also says that by 2025 China should install 50 GW of building-integrated photovoltaic solar power plants. Local authorities have been instructed to explore the possibility of installing solar photovoltaic systems on roofs, walls, and other accessible surfaces, including on municipal buildings. Another interesting requirement: 100 million square meters of real estate must be provided with heat using geothermal energy. The Chinese are actively promoting the use of electricity to power buildings – "for cooking, hot water, and heating," the use of heat pumps. By 2025, the share of electricity in the energy consumption of buildings should exceed 55%.

China is also working towards the introduction of renewable energy sources. In 2021, 6 different measures were taken, among which: Carbon Peaking, carbon neutral energy sector plan, 2021 Biomass Power Generation Project Construction Work Program, Notice on Matters Concerning the Development and Construction of Wind Power and Photovoltaic Power Generation in 2021, Opinions on Strengthening the Green and Low-Carbon Construction of County Towns and others.

The main goal of India's energy policy is to provide energy resources, in conditions of their scarcity, to the country's rapidly developing economy through the development of alternative energy sources, especially nuclear, solar, and wind energy. At the same time, unlike many other states, India's energy policy has never been formalized as a single policy document and is a set of laws adopted by the Indian Parliament and various government programs, action plans, and other documents (Mastepanov, 2020). The main such acts, programs, and decisions adopted in the last 20 years are Hydrocarbon Vision 2025 Program, developed in 2000 (describes the policy in the field of exploration, production, and use of hydrocarbons for 2025); Energy Conservation Act of 2001 (is the legal basis for energy efficiency measures); Electricity Act 2003 (according to this law, a new version of the National Electricity Plan is developed every 5 years, NEP; National Action Plan on Climate Change, NAAPC from 2008, development of this plan in subsequent years, several targeted programs were adopted: to stimulate/develop energy efficiency (2009), solar energy (2010), smart grids (2015), critical technologies (2017), the transformation of mobility and creation of a new generation of batteries for storing large amounts of energy (2019), etc. In 2018, the New National Electricity Plan - NEP-2018 was adopted, calculated until 2027. In 2019 Adopted India Cooling Action Plan, ICAP, etc.

The Department of Energy has waived charging for the Interstate Transmission System (ISTS) for electricity generated from solar and wind sources for projects that will be put into operation before June 30, 2025 (Ministry of Power, 2021). This will facilitate the development of solar, wind, Pumped Storage (PSP), and Battery Energy Storage Systems (BESS), fuel trading on energy exchanges, and uninterrupted power transmission across the states. Delhi Energy Minister Satyendar Jain has directed that all buildings in the city such as shopping malls, hospitals, hotels, and residential offices that have car parks with a capacity of more than 100 vehicles reserve five per cent of this space for electric vehicles (EVs) and charging points (ET EnergyWorld, 2021).

Rural India Program - Gram Ujala offers carbon finance. LEDs will be available for as little as Rs 10 per household in exchange for old incandescent bulbs in working order. Each household will receive up to 5 LEDs. India's Minister of Energy Gram Ujala will have a significant impact on India's actions on climate change. The book value and markup on the cost of the LED will be recovered from earned carbon credits. As part of the Union Budget of India for 2021/22, the duty on solar inverters is increased to 20%, and on solar lights from 5% to 15% (Government of India, 2022).

The Indian state of Kerala has announced a 50% reduction in vehicle tax for electric vehicles, fuel cells, and fully hybrid batteries (EV) over 5 years in the 2021-2022 state budget. Kerala State Electricity Board (KSEB) plans to install 236 electric vehicle charging stations in 2021-22. 3,000 Kerala State Road Transport Corporation diesel vehicles to be converted to liquefied natural gas (LNG) engines. The Kerala Financial Corporation will provide loans for the purchase of electric vehicles at an interest rate of 7%. TKIIFB will also provide 2.5-billion-yen (~$34.2 million) for the installation of small rooftop solar projects under the Renewable Energy Service Company (RESCO) model. The state also announced incentives for the construction of environmentally friendly buildings. Solar panels will be installed in all public schools in the state as part of a ~$16.4 package to improve their

infrastructure and facilities (Prasad, 2021). The Chandigarh city government is providing incentives to encourage rooftop installations. The announced incentives include a 30% subsidy and a cash bonus of Rs 100,000 for the most efficient Community Welfare Associations in Chandigarh. Delhi's electric vehicle policy aims to ensure that 25% of all new vehicle registrations in 2024 are battery electric vehicles. The Delhi government will provide an incentive of up to Rs 30,000 for two-wheelers, cars, e-rickshaws, and cargo vehicles, while for cars, it will provide an incentive of up to Rs 150,000 (The Hindu, 2020).

High school and college students who buy electric two-wheelers will receive a government subsidy of Rs 12,000, while rickshaw drivers and self-employed individuals who buy electric three-wheelers will receive a subsidy of Rs 48,000 per vehicle. Planned to produce 10,000 electric two-wheelers and 5,000 electric three-wheelers this fiscal year alone (Saur News Bureau, 2020).

Loans to farmers for the installation of solar power plants to solarize grid-connected agricultural pumps and loans for the installation of compressed biogas (CBG) plants were included in new categories to be financed under the priority sector. In addition, credit limits for renewable energy sources were increased (doubled). The Ministry of Railways, intending to transform Indian railways into green railways by 2030, has taken some major initiatives to mitigate global warming and combat climate change. Railway electrification, energy efficiency improvements for locomotives and trains and fixed installations, environmental certification of installations/stations, installation of bio-toilets in railcars, and the transition to renewable energy sources are part of its net zero carbon strategy. The Andhra Pradesh government has promised farmers 9 hours of free electricity during the day, this has been approved by allocating solar energy to meet this supply requirement. Cabinet previously approved 10,000 MW solar power projects for this purpose (ET EnergyWorld, 2020).

Thus, we observe that the policies adopted by countries are quite diverse.

4. RESULTS AND DISCUSSION

The study showed that energy efficiency policies applied by the US, China, and India are positively associated with reducing energy intensity. The dynamics of energy intensity reduction and countries' policies as a cumulative total are presented in Figures 8-10.

As experience shows, at the initial stage of the implementation of energy conservation policy, even in countries with developed market economies, the state plays a fundamentally important role. The primary role of the state is to form common goals, adopt a legislative and regulatory framework, implement state programs, and develop mechanisms for financial support for the fulfilment of tasks. This confirms our analysis. The share of administrative policies in the US and China was 76%, and India 60%.

Economic conditions and financial incentives are important prerequisites for the successful introduction of new technologies. Policies aimed at improving energy efficiency and developing renewable energy must provide at least the necessary guarantees for the return on investment following the implementation of energy-saving projects. More economic policies are applied in the US than in India and China (37%, 30%, and 26% respectively).

Standards in production, industry, housing, and communal services are the most important part of the energy efficiency policy of any state. The analysis showed that in all three countries, the largest number of policies are in sectors related to residential, services, power buildings, heat, and utilities, services. Today, you can often find statements about the creation of energy-efficient homes, and the labelling of electrical appliances is already becoming the most important characteristic of goods. Politicians in this area account for 52% each in the US and India, and only 40% in China. As for the labelling of products, according to many researchers. More research is needed to fully understand whether labelling improves the choice of energy-efficient products (Cattaneo, 2019). A topic for further research may be the awareness and attitude of the population of different countries to the labelling of goods.

Standards, information programs, subsidies, and taxes target the same type of external barriers. However, standards are a weaker tool than other interventions because they do not influence behaviour by reducing the use of energy-consuming products and result in loss of welfare by limiting the available choice. Information programs, subsidies, and taxes represent a more direct and effective response to targeted external barriers (Cattaneo, 2019).

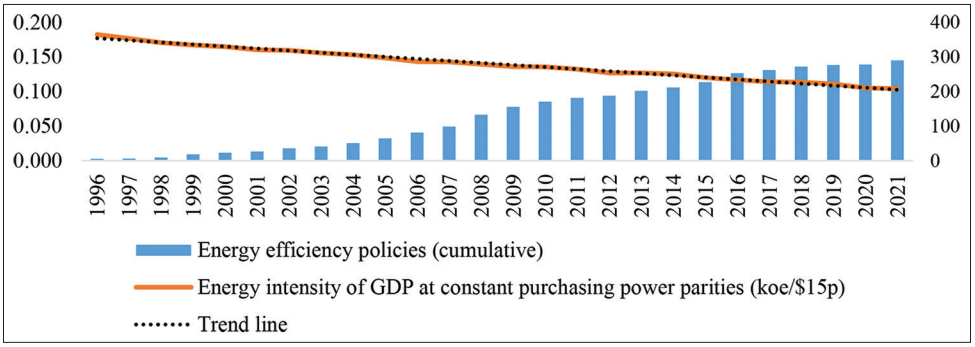
At all stages of the implementation of the state policy in the field of improving energy efficiency and developing the potential of renewable energy, the campaign to raise awareness of decision-makers about the possibilities of implementing energy-saving measures and existing measures to stimulate energy efficiency and renewable energy plays a crucial role. To date, India has become the leader among the analyzed countries (38%), in the USA - 28%, and in China only 11%.

In our opinion, the strengthening of information policies in the field of energy efficiency can play an important role in achieving the goals. Modern information technology tools, in particular the Internet and websites, can have a significant impact on energy-saving decisions. Evaluation of the information presented on the Internet by public and private companies will be the topic of a separate study. The study showed that developing countries need to increase the share of measures related to awareness and awareness of both the population and businesses about measures of state support for energy efficiency and energy saving in the country.

The results of the study showed that China is now pursuing a more centralized policy, although the example of the United States and India shows that measures taken in individual states have great potential. We agree that the Chine government should encourage the diffusion of technology across regions (Zheng et al., 2021).

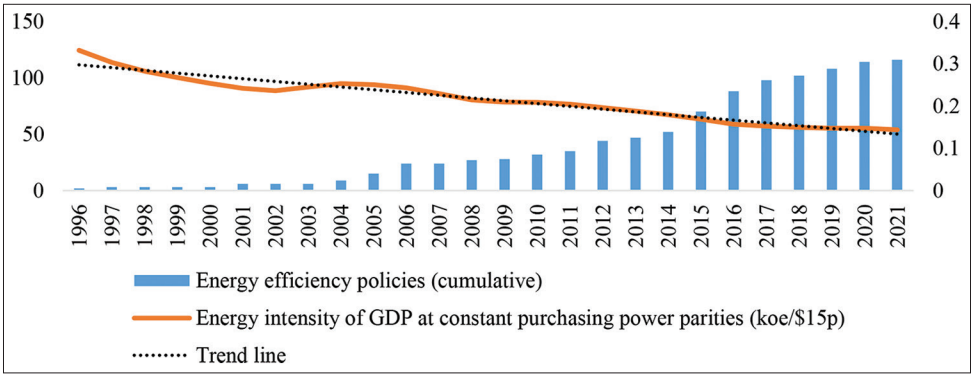
Spatial regression models show that the presence of young families, college-educated residents, detached houses, and large

Figure 8: Energy efficiency policies (cumulative) and energy intensity of GDP, USA



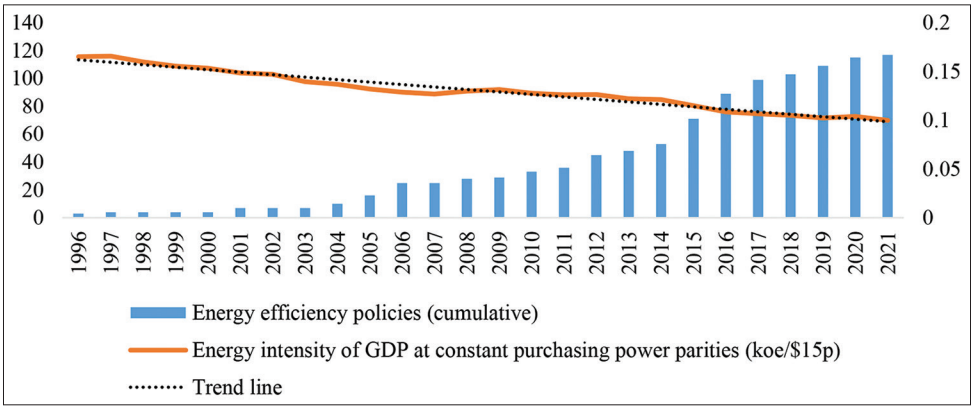
Source: World energy and climate statistics - yearbook, 2022 and policy database – data and statistics

Figure 9: Energy efficiency policies (cumulative) and energy intensity of GDP, China



Source: World energy and climate statistics - yearbook, 2022 and policy database – data and statistics

Figure 10: Energy efficiency policies (cumulative) and energy intensity of GDP, India



Source: World energy and climate statistics - yearbook, 2022 and policy database – data and statistics

households have a positive effect on energy efficiency scores, while real estate market activity, personal incomes, the presence of self-employed residents, and the efficiency levels of the existing housing stock have a damping effect. National incentives for policy implementation, which are distributed through individual local governments also encourage the implementation of energy efficiency assessments. It is important to how national policies are implemented on the ground (Morton et al., 2018).

At the same time, public policy measures depend on the political situation, cultural differences, and the At the same time, public policy measures depend on the political situation, cultural differences, and the mentality of the population, which must be considered when making decisions. For example, a US study suggests that political partisanship may be shaping the policy. There is strong evidence that electric utilities in states dominated by the Republican Party are less likely to invest in energy efficiency than those in states governed by the Democratic Party (Adua and Clark, 2020). Researchers agree that policies and tools used should support each other, not conflict (Wiese et al., 2018; Trencher and van der Heijden, 2019). The analysis showed that the United States managed to achieve results, thanks, among other things, to a balanced state policy in the field of energy efficiency. In our opinion, the complementarity of the policies pursued will provide a synergistic effect and allow countries to achieve their energy efficiency goals.

5. CONCLUSION

Even though energy efficiency policies have been applied in almost all countries for a long time, the need for them remains. As the experience of implementing energy efficiency policies in the United States, India, and China shows, if the state's attention in this area is weakened, a rollback can occur, which is expressed in a slowdown in the decline in the energy intensity of GDP and the carbon intensity of the economy. This means that the situation of "market failure" in the world energy markets persists, and the "energy efficiency gap" is still relevant even in such "advanced" countries in the field of energy efficiency as the USA, India, and China.

Our analysis showed that the best results come from the coordinated and complementary application of all four types of energy efficiency policies: legal, regulatory, economic, technical, and informational. Of the countries surveyed, the United States has the most balanced and systemic response, with much of the stimulus coming from fine-tuning the tax system. However, this does not mean that successful US energy efficiency policies can be transferred to other countries without adaptation. In the context of significant infrastructural and cultural heterogeneity between different regions of the country, which is observed in all three countries, the competent adaptation of all policies at the regional level takes on more importance. The study showed that developing countries need to increase the share of measures related to awareness and awareness of both the population and businesses about measures of state support for energy efficiency and energy saving in the country. In our opinion, strengthening energy efficiency information policies can play an important role in achieving carbon reduction goals. Modern information technology tools, in particular the Internet and websites, can have a significant impact on energy-saving decisions. The assessment of the information provided on the Internet by public and private companies on this issue will serve as a topic for further research by the authors.

6. FUNDING

This publication has been supported by the RUDN University Scientific Projects Grant System, project № 061608-2-000.

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